ANSWERS: Crystal Ball questions on Acids and Bases

1. An indicator is a substance that will change colour in an acidic or alkaline solution.
Litmus is a good indicator as it has distinctly different colours in acids (red colour) and bases (blue colour). However, litmus dies not give an idea of the strength of a particular acid or base.
Alizarin yellow isn't a very good indicator as it can only distinguish between a strong base of pH 12 – 13 with a violet colour. All the other acid, neutral and weak bases are shown with a yellow colour for Alizarin yellow. Similarly, Thymol blue isn't a very good indicator because it can only distinguish between a strong acid, pH of 1 with a red colour whereas weaker acids, neutral and basic substances show as a yellow colour with thymol blue.
Bromocresol green and purple are good indicators because they also change colour but only give a general idea of the pH level. Bromocresol green shows strong acids with a pH of 1 - 3 with a yellow colour, whereas all the other pH levels are a blue colour. Bromocresol purple shows weak and strong acids with a pH of 1 – 5 as a yellow colour whereas all the other pH levels show up as a violet colour.

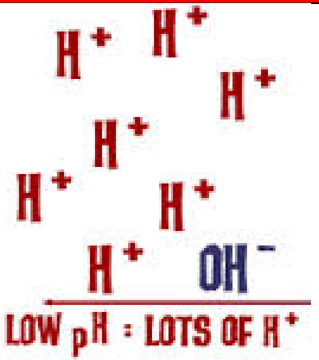
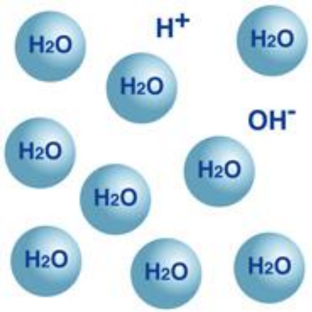
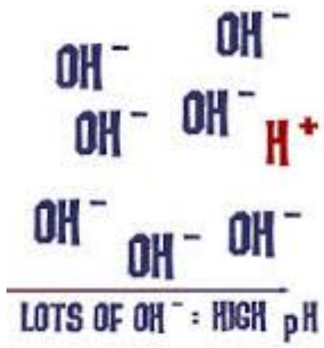
Universal indicator is excellent because it is made up of a mixture of many different coloured dyes and has a range of different colours which indicate a specific pH range. Acids are a red, orange or yellow colour in Universal indicator. A strong acid (eg HCl) with a lot of H^+ ions, has a pH of 1 – 3 and will be a red colour in Universal indicator. A weak acid (eg vinegar) has a lot less H^+ ions, a pH of 4 and will be an orange colour with Universal indicator. An even weaker acid would show as a yellow colour with Universal indicator as the pH is between 5 and less than 7.

Universal indicator also indicates a neutral substance, a pH of 7 with a green colour.
The different strengths of bases are also indicated by Universal indicator, bases will show as a blue, purple or violet colour. A strong base (eg NaOH) with a high concentration of OH- ions and pH of 11 – 13 will show a violet colour with

indicator. A weaker base such a ammonia solution with a pH of 10 will show as a purple colour and very weak bases such a gentle soaps with a pH range of above 7 to 9 will show a blue colour with Universal indicator.

Of the choice of indicators provided in the table Universal indicator has the greatest range of colours and provides a clear idea as to the specific pH range of a substance, so I would choose it to be the "best" indicator of the choices available.

2.

type of solution	**stomach acid**	**pure water**	**oven cleaner**
scientific name	hydrochloric acid	water	sodium hydroxide
chemical formula	HCl	H_2O	NaOH
pH range or number	1 - 2	7	12 - 14
colour in Universal indicator	red	green	purple or violet
sketch of a beaker showing H^+ and OH^- ions of the solution	 *the Cl^- ions have not been shown*		 *the Na^+ ions have not been shown*

3. An indicator is a substance that changes colour in an acid or alkali.
Some plants such as yellow marigold and yellow dandelion are not good indicators because they are the same colour in acid, base and neutral solutions.

Some plants parts would be good at distinguishing between an acid and alkali solution but not neutral as they are the same colour in neutral as well as acid or alkali, for example red rose, white rose, white daisy and raw beetroot.

Similarly other plant parts don't have different colours between acid and alkali solutions but do have a different colour in water so could help distinguish them, examples are orange nasturtium and green spinach leaf.

Some excellent indicators in the list above are red hibiscus, red oleander, red canna, red geranium, red dahlia, mauve impatiens, purple laslandra, purple aster and red cabbage leaf. They are excellent indicators of acidic, basic and neutral solutions because they have different colours in each of these solutions eg red hibiscus is has 3 distinctly different colours: pink in neutral solution, orange in acid and blue-green in alkali solutions.

The table implies that usually plant petals are used as indicators but other parts such as leaf and the flesh eg in beetroot could be used. There is no mention of parts such as stem or roots being good indicators.

4. Firstly use a tweezers to dip a piece of blue litmus paper into each of the 4 solutions. One solution will turn the blue litmus a red colour – that is ethanoic acid.
The other solutions will have no effect on blue litmus paper.
Now use tweezers to dip a piece of red litmus into the remaining 2 solutions, two will turn the red litmus paper a blue colour, they are sodium carbonate and sodium hydroxide.
One of the solutions had no effect on either the red nor blue litmus paper, that solution must be the pure water.

To distinguish between the two alkalis (sodium carbonate and sodium hydroxide) add a few mL's of ethanoic acid to each of them. The sodium carbonate will form bubbles as carbon dioxide gas is produced.
The remaining solution is sodium hydroxide.

5. The advantage of antacids is that they can neutralise excess stomach acid (hydrochloric acid). The word and chemical equations are:
magnesium hydroxide + hydrochloric acid → magnesium chloride + water
$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide
$CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

A disadvantage of taking calcium carbonate tablets is that they react with hydrochloric acid in the stomach to produce carbon dioxide gas which may result in a person feeling a bloated stomach and burping a lot.

Gas isn't produced with antacids containing magnesium hydroxide so most people would prefer to take antacid with magnesium hydroxide as an active ingredient as opposed to calcium carbonate.

6. a) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

b) - error with chemical formula
copper oxide is not CuO_2 but CuO because copper oxide is made up of the ions, one Cu^{2+} ion : one O^{2-} ion
- error with the word equation
acid + base → salt + water

There is no CO_2 nor H_2 gas produced

- error with the salt formed

zinc sulfate cannot form from copper oxide and sulfuric acid, the correct salt formed is $CuSO_4$

- Finally, the correct chemical formulas are

CuO and H_2SO_4 and $CuSO_4$ and H_2O

So, with the same number of reactant atoms as products, the fully balanced chemical equation is

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$

7. The word and balanced equations for the formation of zinc sulphate can be

zinc oxide + sulphuric acid → zinc sulphate + water

$ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$

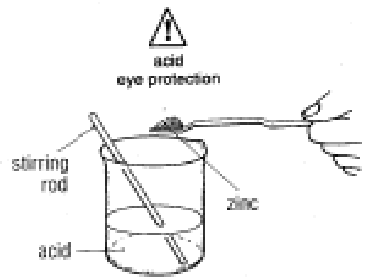
or

zinc hydroxide + sulphuric acid → zinc sulphate + water

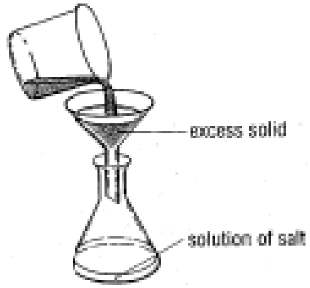
$Zn(OH)_2 + H_2SO_4 \rightarrow ZnSO_4 + 2H_2O$

1 Put about 25 cm^3 of dilute sulphuric acid in a small beaker.

2 Add zinc powder, one spatula measure at a time until no more dissolves.Stir the mixture with a glass rod to help the zinc to dissolve.



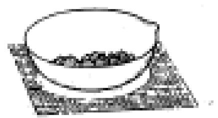
3 Filter the mixture. Collect the **filtrate** in a conical flask.
The filtrate is zinc sulphate solution.
What do you think the **residue** is?



4 Put the filtrate in an evaporating basin.
Carefully evaporate the filtrate to half its original volume. (Heat gently to stop the solution from spitting.)

5 Leave the basin to cool.
The crystals of zinc sulphate should form slowly.

What do your crystals look like?



8. Carbonic acid (H_2CO_3) is an acid, it will react with limestone/calcium carbonate ($CaCO_3$) which is a base

acid + base → salt + water

Because the base is a carbonate, carbon dioxide will also be produced.

The limestone will dissolve so formations such as stalactites and stalagmites may become shorter in length or dissolve altogether. Some caves may also be formed as has been the case at Waitomo Caves.

The word equation for the reaction will be
carbonic acid (or hydrogen carbonate) + calcium carbonate → a calcium salt + water + carbon dioxide

9. The reaction between hydrochloric acid and calcium carbonate is a neutralisation reaction.

The word equation for the reaction is
hydrochloric acid + calcium carbonate → calcium chloride + water + carbon dioxide

The balanced chemical equation is
$HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$

Bubbles will be visible as carbon dioxide gas is produced. To prove that carbon dioxide gas is produced the gas can be bubbled into limewater and the limewater will turn from colourless to a milky/cloudy colour.

Water will also be produced, the test for water is blue cobalt chloride paper will turn a pink colour.

The reason that a chloride salt is formed is because the acid used was hydrochloric acid, if sulphuric acid was used a sulphate would have formed, nitric acid would have formed a nitrate.